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MK 12 SURFACE SUPPORTED DIVING SYSTEM COMPONENT CORROSION PROTE--ETC(U)
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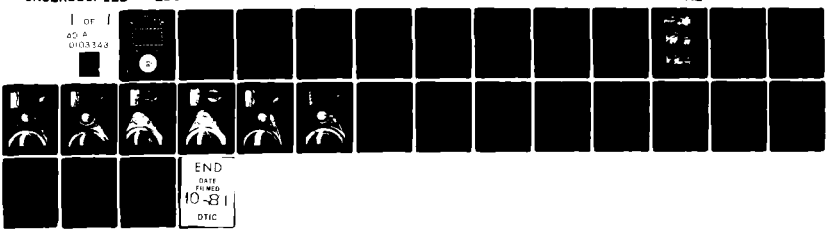

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DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407

NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 12-80

MK-12 SURFACE SUPPORTED DIVING SYSTEM COMPONENT CORROSION PROTECTION EVALUATION

LT(N) E. H. PAHL, CF

December 1980

Approved for public release; distribution unlimited

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Improved casting techniques, improved and alternate coating systems, and uncoated aluminum low pressure manifold blocks of the MK-12 Surface Supported Diving System mixed gas recirculator, all with anodic protection, were tested for corrosion resistance in a simulated sea water environment. Incorporation of anodic protection and re-consideration of coating systems are recommended.

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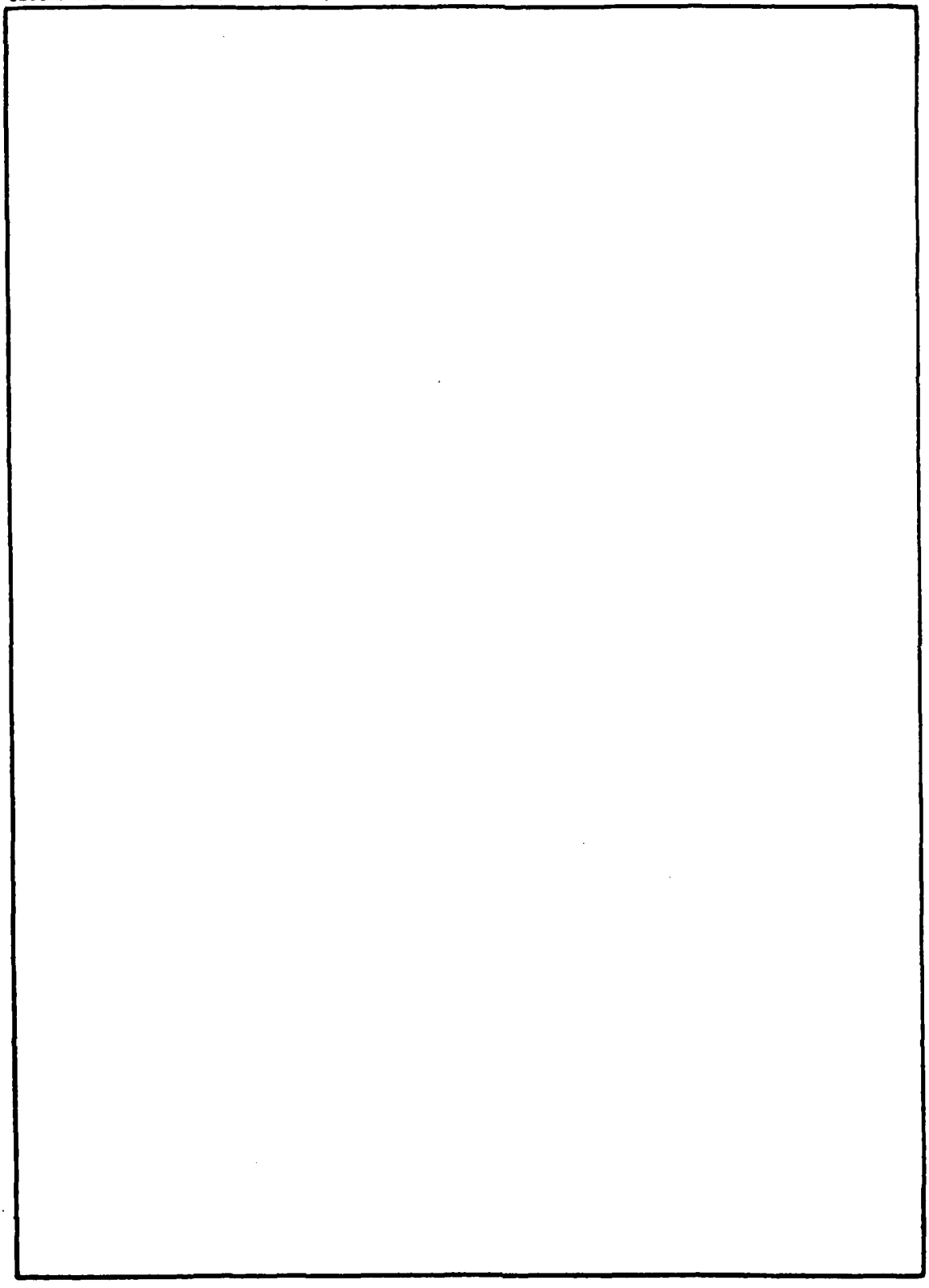

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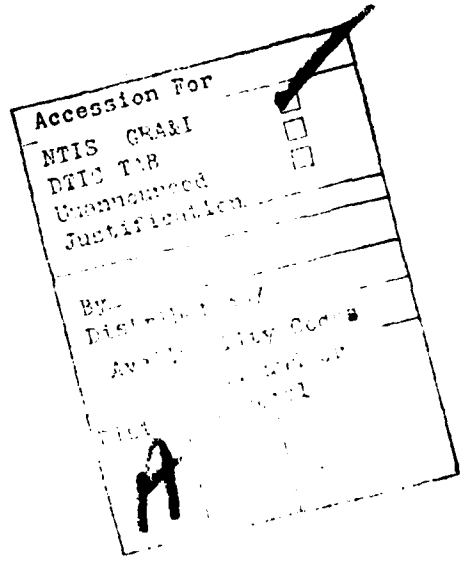


LIST OF ILLUSTRATIONS

ABSTRACT

Improved casting techniques, improved and alternate coating systems, and uncoated aluminum low pressure manifold blocks of the MK-12 Surface Supported Diving System mixed gas recirculator, all with anodic protection, were tested for corrosion resistance in a simulated sea water environment. Incorporation of anodic protection and re-consideration of coating systems are recommended.

I. INTRODUCTION

After approximately 12 months of operation the low pressure manifold block of the initial production version of the MK-12 Surface Supported Diving System (SSDS) mixed-gas recirculator was found to have surface corrosion. Component testing at the Navy Experimental Diving Unit (NEDU) in June and July 1980 duplicated this field experience.

Before requiring extensive redesign of the component, it was determined that the low pressure manifold block would be retested. An improved casting technique, anodic protection on each manifold block, alternate coating systems, bare aluminum, and an Impreglon system, with stringent quality control exercised during application, would be tested.

In February and March 1981 NEDU tested six blocks (five cast with an improved casting technique and one initial production version). See paragraph 2.A. for details of the variation of the blocks.

II. TEST PROCEDURE

A. Test Sample

The test sample consisted of six low pressure manifold blocks mounted in pairs on a fiberglass base in a manner which would permit the mounting of appropriate recirculator components, less case, on each block, see Figure 1. Zinc anodes were located on each manifold block. Manifold block characteristics were:

Block identification	Type and Coating
A	Improved casting technique (ICT) manifold block with fluidized epoxy coating, inside and outside.
B	ICT manifold block with Impreglon coating, 120 inside and 218 outside.
C	ICT manifold block with Impreglon coating, 129 inside and 218 outside.
D	ICT manifold block with Impreglon coating, 120 inside and 218 outside.
E	ICT manifold block, uncoated.
F	Initial production manifold block with original Impreglon A and C coatings.

B. Test Plan

The test plan is provided in Appendix A. The test set up is shown in Figure 2.

C. Additional Test Procedures

1. Brine Solution. The test blocks were immersed in a brine solution of 1.022 specific gravity contained in large plastic garbage cans. The composition of the solution is provided in Appendix B.

2. Routine Maintenance. After each diving day, all test recirculator canisters were emptied of CO_2 absorbant, and each test assembly was thoroughly flushed with fresh water.

Figure 1. Low Pressure Block Test Sample Before Test

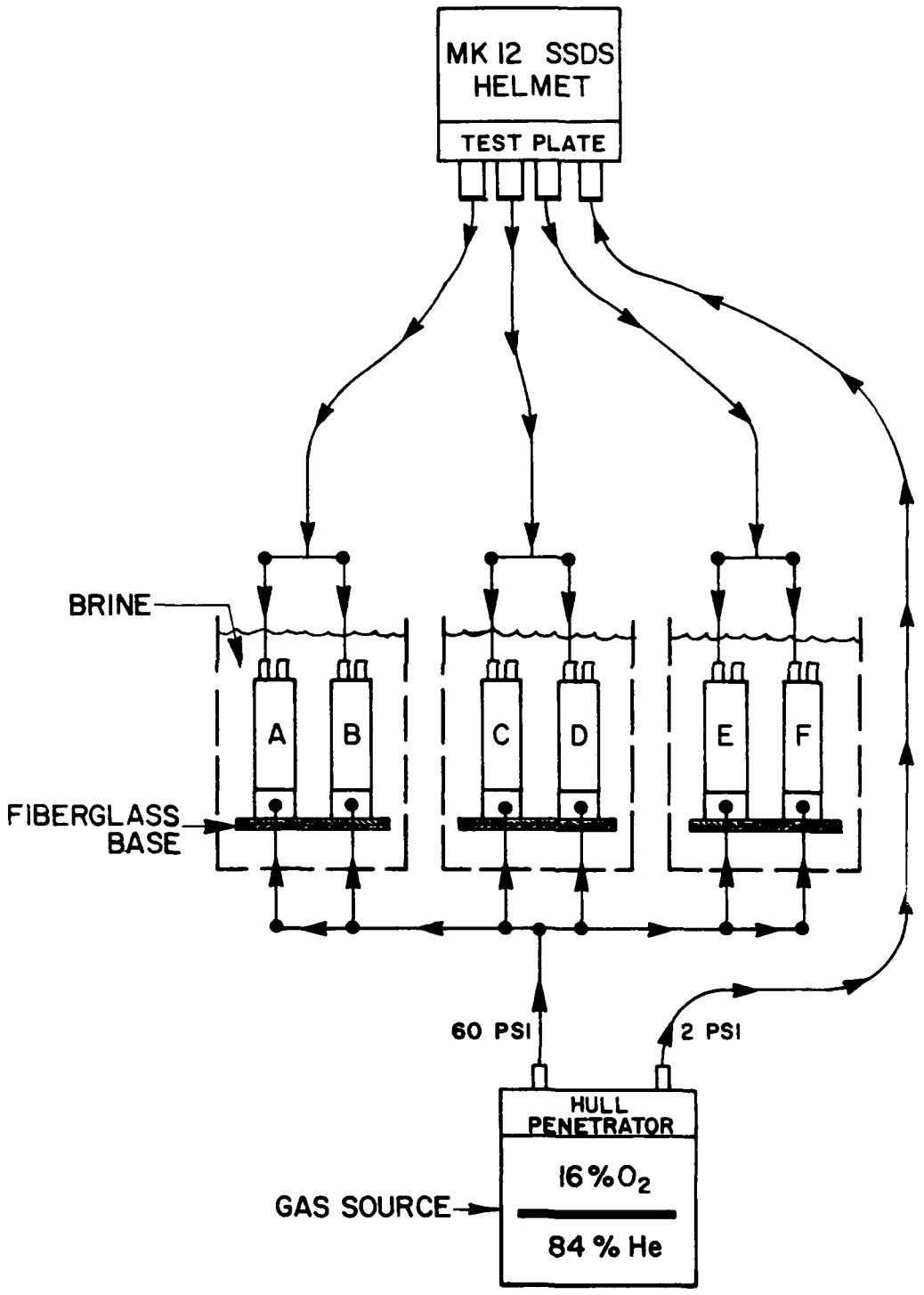


Figure 2. Test Setup

III. RESULTS AND DISCUSSION

A. General

Inspections. Each test manifold block was visually examined in accordance with the Test Plan. No evidence of major corrosion was discovered in these inspections. A record of the inspections is contained in Appendix C.

B. Specific

1. Zinc Anodes. The zinc anodes were observed to have sacrificed a small part of their mass due to protective electrolytic action.

2. Protective Coatings

a. Manifold Block A. The epoxy coating showed no corrosion or pitting on external surfaces. It showed slight signs of crevice corrosion in threads which were not "O" ring protected.

b. Manifold B, C, D. Impreglon 120 inside, 218 outside showed little or no pitting on external surfaces. It showed slight signs of crevice corrosion on threads which were not "O" ring sealed.

c. Manifold Block E. Bare aluminum - showed no corrosion or pitting on external surfaces. It showed slight signs of crevice corrosion on threads which were not "O" ring sealed.

d. Manifold F. Control Block - Impreglon A and C coating inside and out. It showed some corrosion and pitting on external surfaces. It showed signs of crevice corrosion on threads which were not "O" ring sealed.

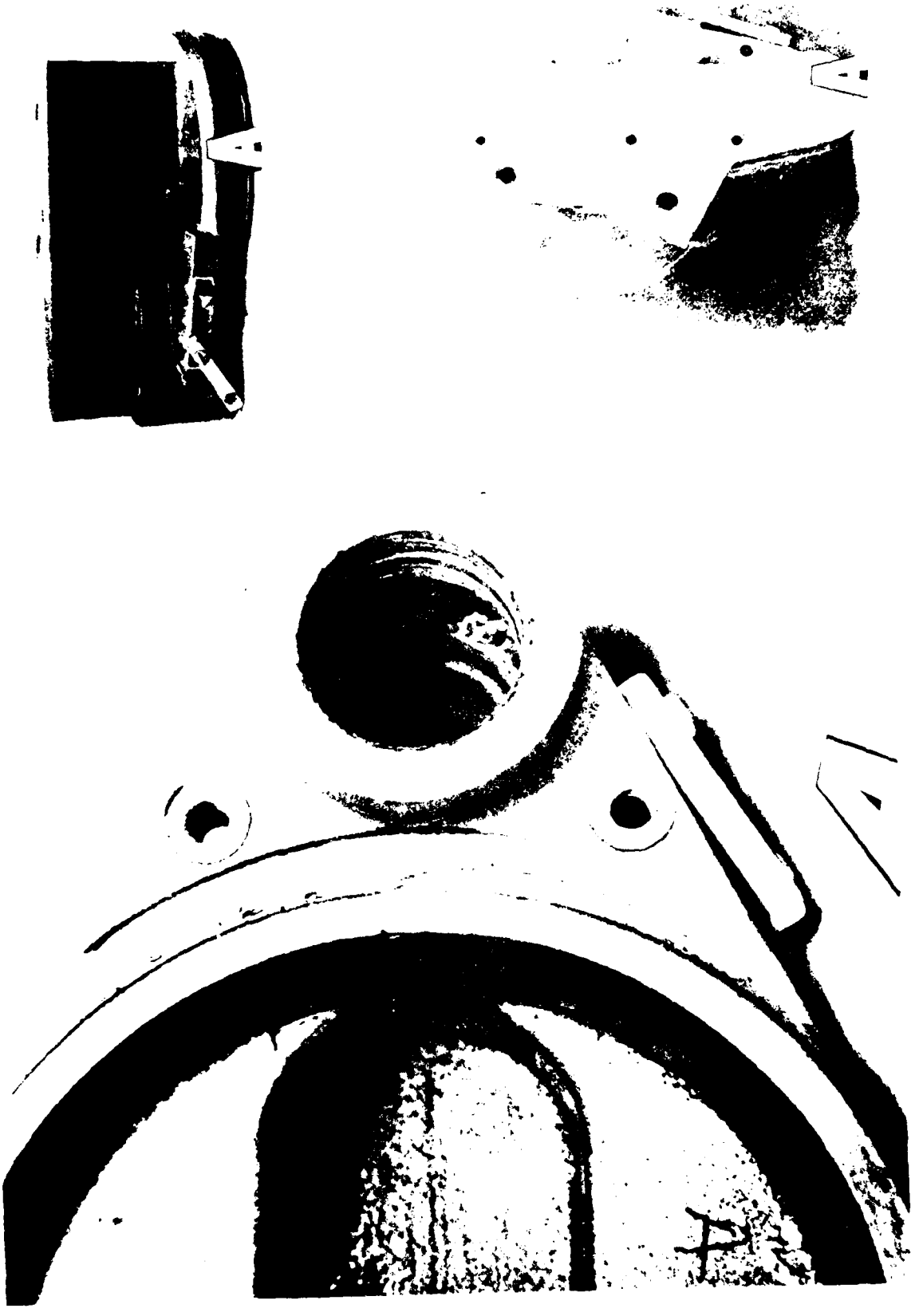
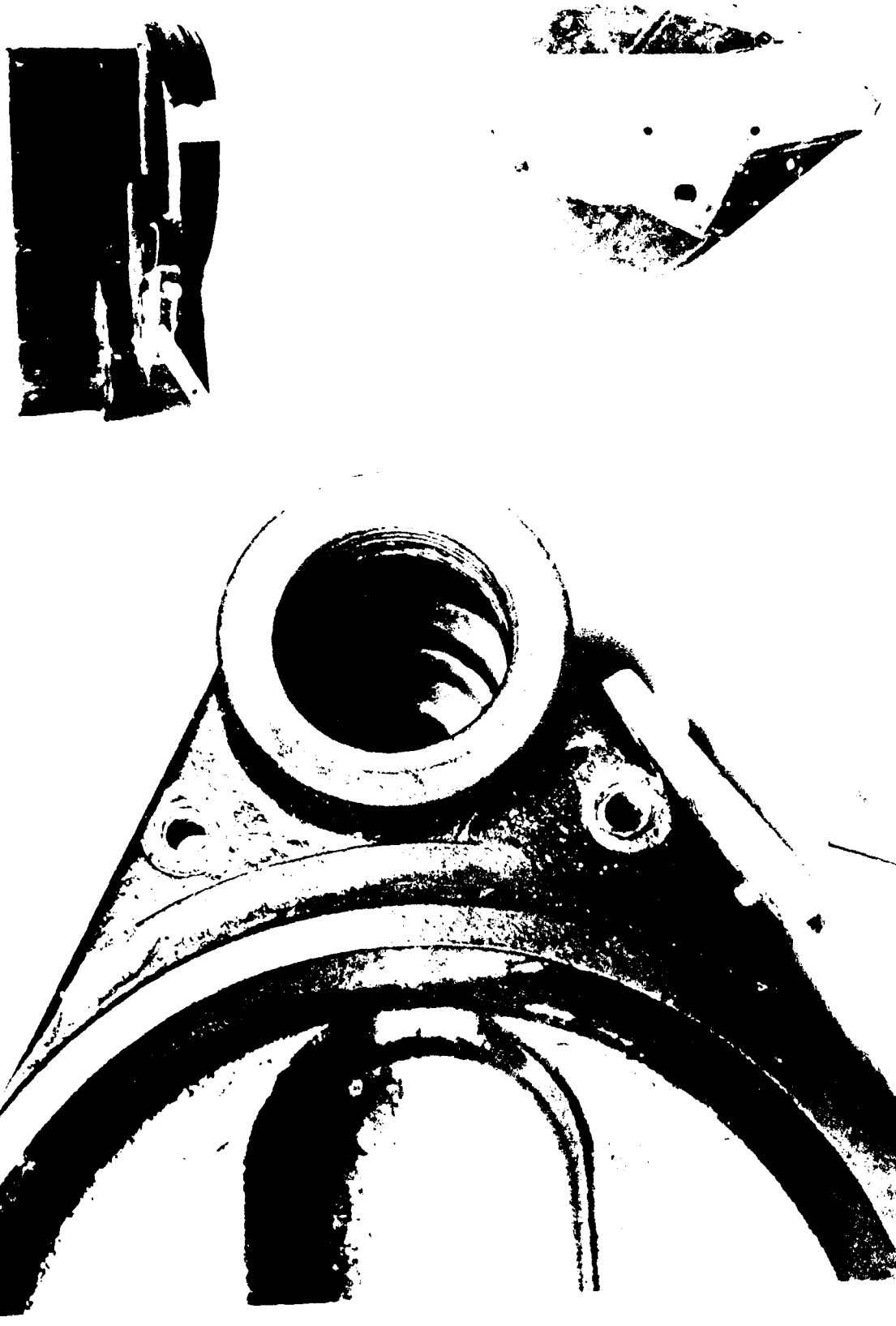


Figure 3. Test Sample A After Test



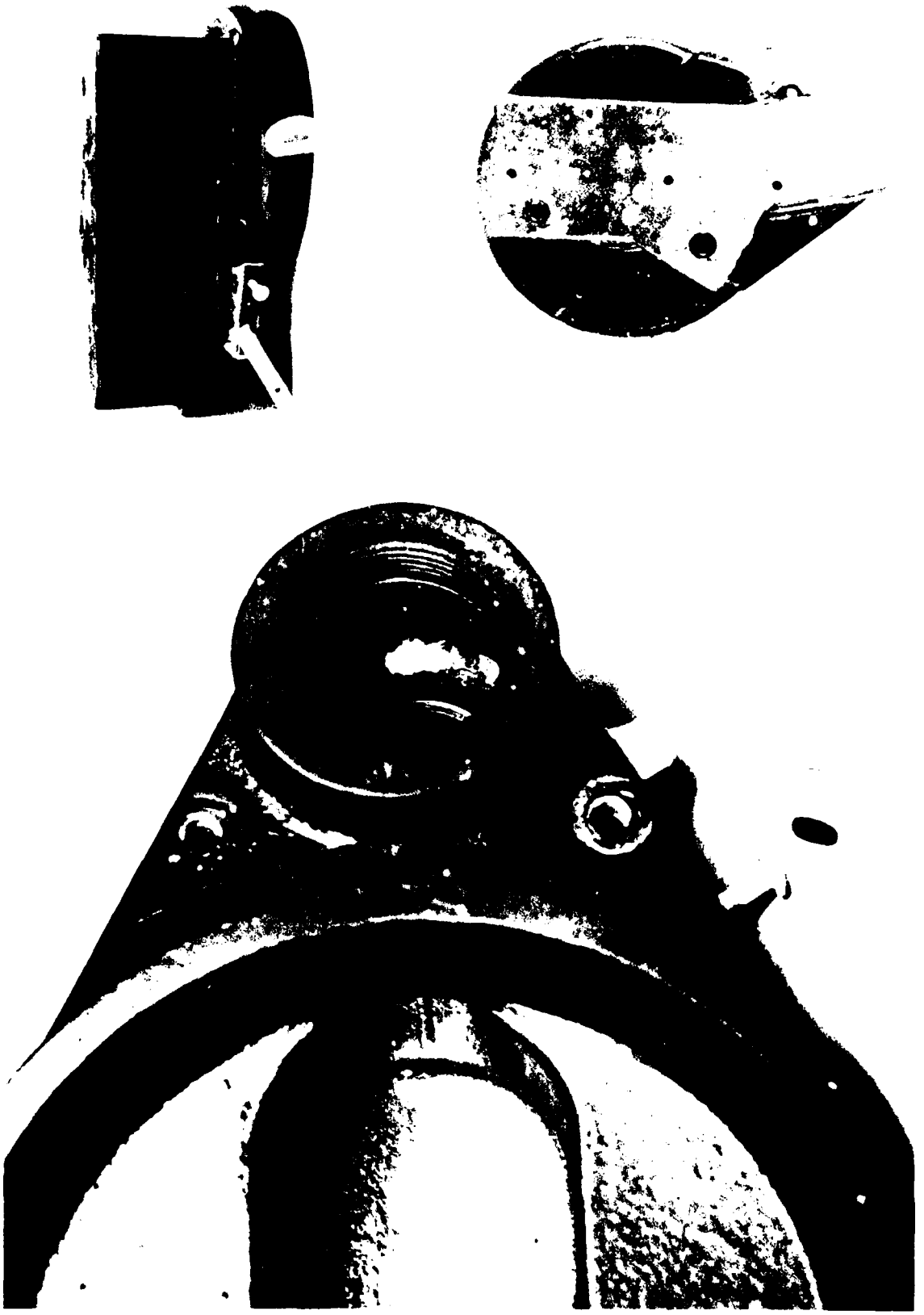


Figure 6. Test Sample D After Test

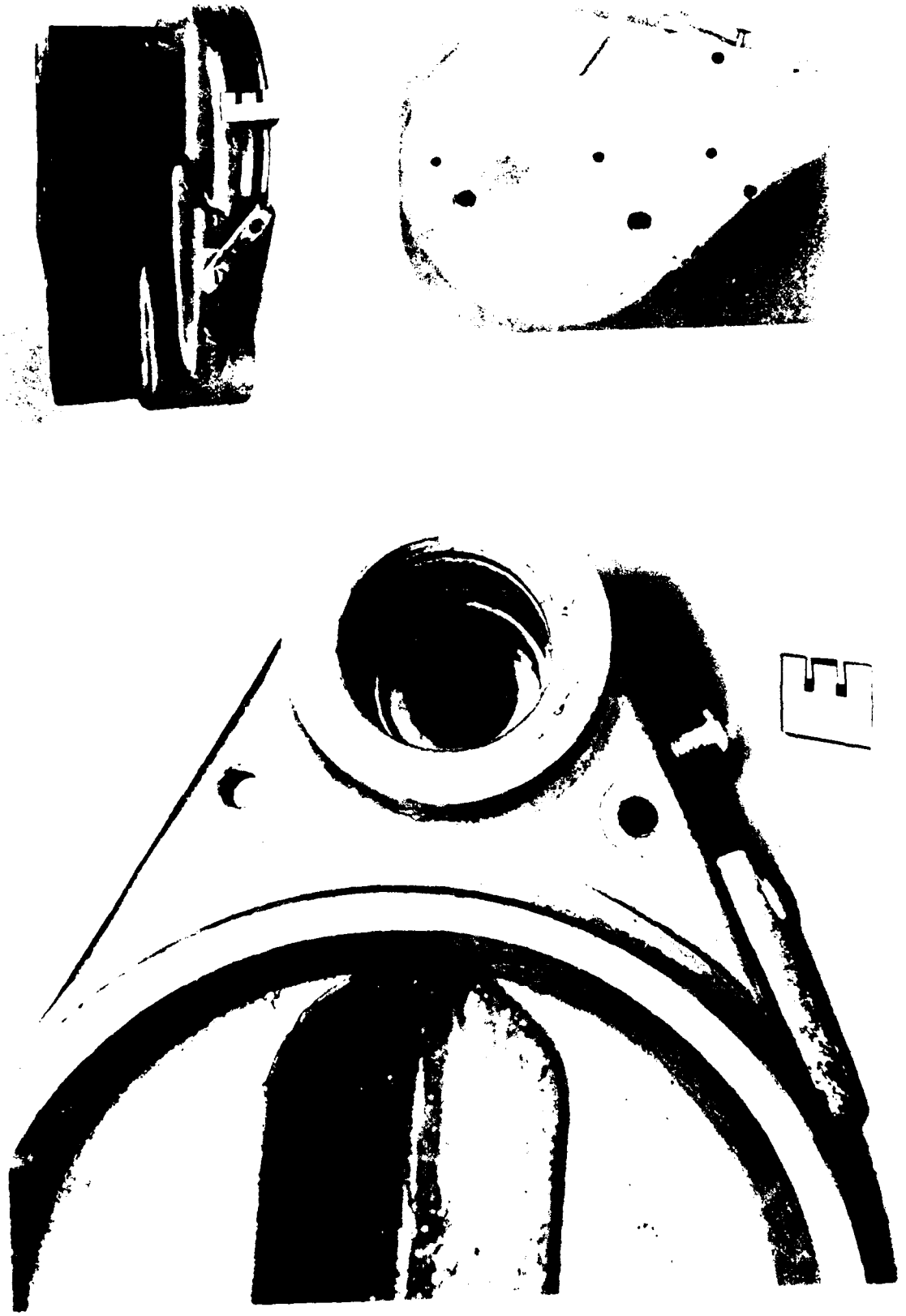


Figure 7. Test Sample E After Test

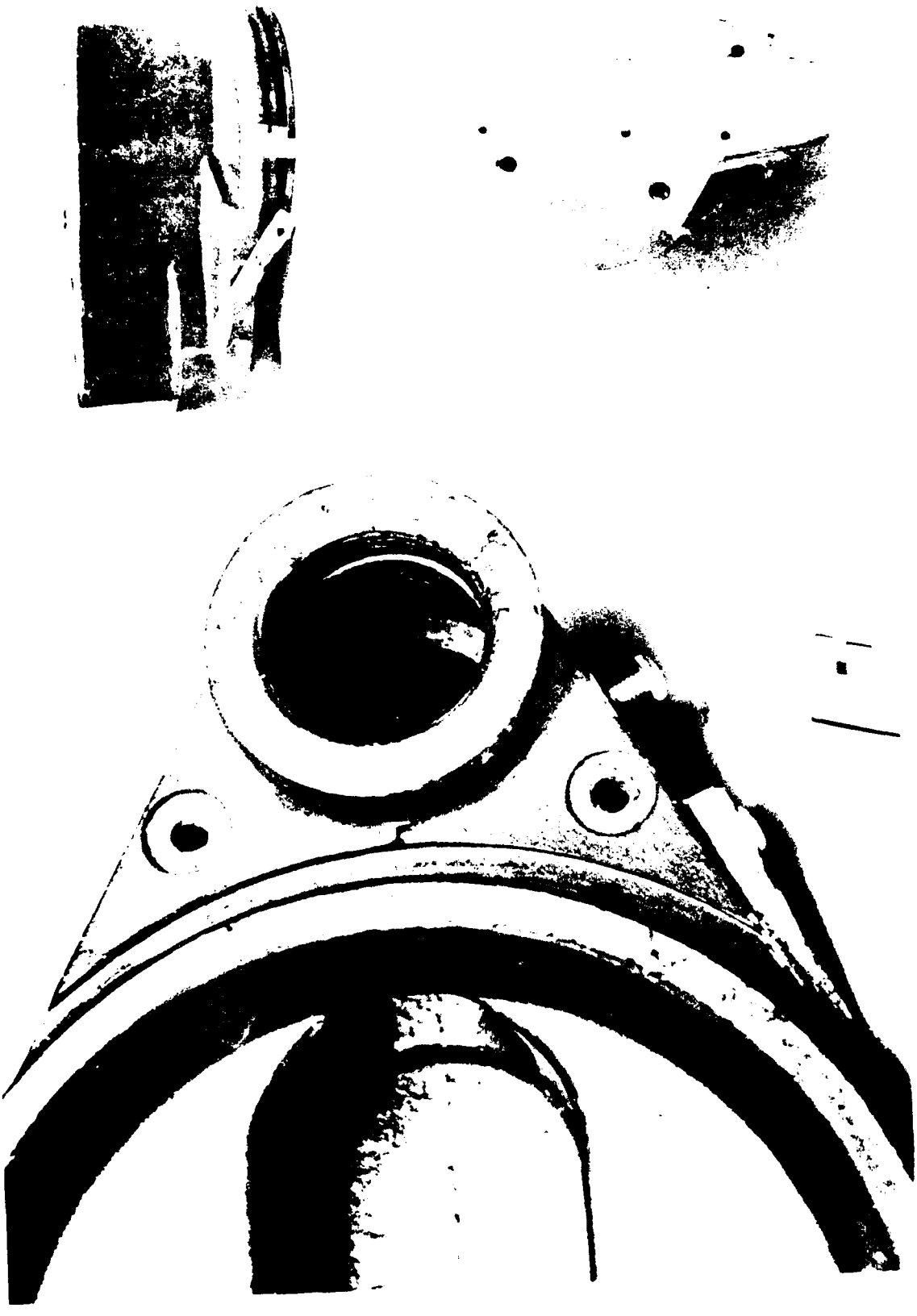


Figure 8. Test Sample F After Test

IV. CONCLUSIONS AND RECOMMENDATIONS

A. Results

1. None of the low pressure manifold blocks cast with the improved technique leaked; either through the casting itself, or at threaded attachment points.

2. Impreglon 120 internal coating proved effective for protection of canister interior surfaces. External coatings tested proved equally effective, preventing major corrosion.

3. The zinc anodes mounted on the manifold blocks provided protection against galvanic corrosion.

B. Recommendations

1. That the improved casting technique (which reduced casting porosity and thus eliminated seepage through the casting) used in this test be specified in future procurements.

2. That additional testing of bare aluminum manifold blocks fitted with zinc anodes be conducted.

3. That use of zinc anodes for the protection of this component against electrolytic corrosion be incorporated in future procurements (no matter what, if any, protective coating system is used), and as a field change to previous issues.

APPENDIX A
TEST DESCRIPTION

1. Background

The aluminum MK-12 SSDS mixed-gas low pressure manifolds exhibited minor leaks due to casting porosity during previous developmental testing. These leaks caused pin-holes in the exterior Impreglon 120 coating which allowed a channel for corrosion. Improved casting methods coupled with an improved exterior Impreglon process (Impreglon 218) may solve the surface corrosion problem. Additionally, some threaded connections have the potential for crevice corrosion or electrolytic corrosion or both. O-ring protection of these areas should prevent corrosion in threaded areas.

2. Sample Low Pressure Manifolds To Be Tested

Six manifolds will be tested.

a. One previously used, original, production-buy manifold.

b. Three new manifolds, manufactured with improved casting technique, coated with Impreglon 120 inside and Impreglon 218 on the outside.

c. One "new casting technique" manifold with no coating.

d. One "new casting technique" manifold with a "fluidized epoxy" coating.

3. Test Procedures

Test Units will be:

a. Pretested for leaks.

b. Connected and pressurized to duplicate operating pressures and flows (60 psi to recirculator; 2 psi to canister; 16% O2 - 84% He).

c. The manifolds will be secured to a fiberglass base with two manifolds per base.

d. Each manifold will be raised from the base by a small spacer between the base and manifold to allow air/brine movement between base and manifold.

e. All manifolds will be fitted with anodic protection devices (zincs).

f. Canisters will be filled with SODASORB.

g. The following dives in brine solution will be accomplished:

(1) Twenty-eight dives to one hundred fifty feet sea water for 20 min

(2) Forty dives to one hundred ninety-one feet sea water for 20 min

(3) Twenty eight dives to two hundred ninety-seven feet sea water for 20 min

h. To prevent unnecessary strain on equipment as well as using excessive amounts of air, the dives will be conducted in the following manner:

150 FSW for 20 min

For each test dive, multiply the bottom time and the decompression stop times to equate to fourteen actual water dives of 150 FSW for 20 min. Each bottom time is increased by fourteen equivalent dive times and each decompression stop is lengthened accordingly to allow the MK-12 SSDS L.P. recirculators to be tested under pressure for the length of time equal to fourteen actual dives.

(a) 150 FSW with 20 min bottom time; 14 dives

20 min x 14 dives = 280 min bottom time

10 min x 14 dives = 140 min at 50 ft

10 min x 14 dives = 140 min at 40 ft (2 days)

Duration of each dive will be 9 1/2 hours per day.

(b) 191 FSW with 20 min bottom time; 25 dives

20 x 15 = 300 min bottom time

7 x 15 = 105 min 80 ft stop

2 x 15 = 30 min 60 ft stop

10 x 15 = 150 min 50 ft stop

10 x 15 = 150 min 40 ft stop (2 days)

20 x 10 = 200 min bottom time

7 x 10 = 70 min 80 ft stop

2 x 10 = 20 min 60 ft stop

10 x 10 = 100 min 50 ft stop

10 x 10 = 100 min 40 ft stop (1 day)

Duration of each dive will be 12 1/2 hrs per day for 2 days with the third day's dive 8 hrs 20 min.

(c) 297 FSW with 20 min bottom time; 7 dives

15 x 7 = 105 min bottom time

7 x 7 = 49 min 130 ft stop

2 x 7 = 14 min 100 ft stop

6 x 7 = 42 min 90 ft stop

6 x 7 = 42 min 80 ft stop

6 x 7 = 42 min 70 ft stop

9 x 7 = 63 min 60 ft stop

10 x 7 = 70 min 50 ft stop

10 x 7 = 70 min 40 ft stop (4 days)

i. Clean and appropriately store at the conclusion of each dive day.

j. Post-test for leaks following the ninety-six dive sequence.

k. Clean and appropriately store for two weeks, with daily observation for evidence of corrosion or Impreglon peel.

l. Post-test for leaks following the two week storage period.

m. Record and correlate all data.

4. Personnel

a. Test Director: LT(N) E.H. PAHL

b. Assistants: EMC(DV) CANTALE
MMC(DV) PENN

5. Safety Precautions

Standard Navy diving precautions as outlined in the U. S. Navy Diving Manual.

6. Logistic Support

a. Engineering Department for mixed gas.

b. EDF Chamber.

7. Report

Results and recommendations will be prepared by NEDU.

8. Classification

Unclassified.

APPENDIX B
BRINE SOLUTION

The brine solution used for immersion of the test manifold blocks was OCEAN 50 SEAMIX. The concentration of elements in this mixture is:

ELEMENTS	CONCENTRATION MG/LITRE	ELEMENTS	CONCENTRATION MG/LITRE
Chlorine	19000	Arsenic	0.003
Sodium	10500	Uranium	0.003
Magnesium	1350	Nickel	0.002
Sulfur	885	Vanadium	0.002
Calcium	400	Manganese	0.002
Potassium	380	Titanium	0.001
Bromine	65	Antimony	0.0005
Carbon	28	Cobalt	0.0005
Strontium	8	Cesium	0.0005
Boron	4.6	Cerium	0.0004
Silicon	3	Yttrium	0.0003
Fluorine	1.3	Silver	0.0003
Nitrogen	0.5	Lanthanum	0.0003
Lithium	0.17	Cadmium	0.0001
Phosphorus	0.07	Tungsten	0.0001
Iodine	0.06	Germanium	0.00007
Barium	0.03	Chromium	0.00005
Indium	0.02	Thorium	0.00005
Zinc	0.01	Scandium	0.00004
Iron	0.01	Lead	0.00003
Aluminum	0.01	Mercury	0.00003
Molybdenum	0.01	Gallium	0.00003
Selenium	0.004	Bismuth	0.00002
Tin	0.003	Niobium	0.00001
Copper	0.003	Thallium	0.00001
		Gold	0.000004

APPENDIX C
CHECK LIST
MK 12 SSDS-MANIFOLD TEST
FEBRUARY 1981

ROUTINE INSPECTIONS AND TESTS	MANIFOLDS					
	A	B	C	D	E	F
1. Anodic protection device fitted. 19 Feb 81						
2. Test Day #1 (150 FSW)						
Pre-dive tested for leaks.	✓	✓	✓	✓	✓	✓
Inspected-corrosion.						
Inspected Impreglon peel.						
Rinsed, cleaned and stowed.	✓	✓	✓	✓	✓	✓
SODASORB Dry	✓	✓	✓	✓	✓	✓
SODASORB Wet						
Comments:						
3. Anodic protection device fitted. ok						
4. Test Day #2 (150 FSW) 20 Feb 81						
Pre-dive tested for leaks.	✓	✓	✓	✓	✓	✓
Inspected-corrosion.	✓	✓	✓	✓	✓	✓
Inspected Impreglon peel.	✓	✓	✓	✓	✓	✓
Rinsed, cleaned and stowed.	✓	✓	✓	✓	✓	✓
SODASORB Dry	✓	✓	✓	✓	✓	✓
SODASORB Wet						
Comments:						
5. Anodic protection device fitted. ok						
6. Test Day #3 (191 FSW) 23 Feb 81						
Pre-dive tested for leaks.	✓	✓	✓	✓	✓	✓
Inspected-corrosion.	✓	✓	✓	✓	✓	✓
Inspected Impreglon peel.	No					
Rinsed, cleaned and stowed	✓	✓	✓	✓	✓	✓
SODASORB Dry	✓	✓	✓	✓	✓	✓
SODASORB Wet						
Comments: Dialectric spray peeling.						
7. Anodic protection device fitted. 24 Feb 81 ok						

CHECK LIST
MK 12 SSDS-MANIFOLD TEST
FEBRUARY 1981

ROUTINE INSPECTIONS AND TESTS	MANIFOLDS					
	A	B	C	D	E	F
8. Test Day #4 (191 FSW)	✓	✓	✓	✓	✓	✓
Pre-dive tested for leaks.	✓	✓	✓	✓	✓	✓
Inspected-corrosion.	✓	✓	✓	✓	✓	✓
Inspected Impreglon peel.		NONE VISIABLE				
Rinsed, cleaned and stowed.	✓	✓	✓	✓	✓	✓
SODASORB Dry	✓	✓	✓	✓	✓	✓
SODASORB Wet						
Comments:						
25 Feb 81						
9. Anodic protection device fitted. ok						
10. Test Day #5 (191 FSW)	✓	✓	✓	✓	✓	✓
Pre-dive tested for leaks.	✓	✓	✓	✓	✓	✓
Inspected-corrosion.	✓	✓	✓	✓	✓	✓
Inspected Impreglon peel.						
Rinsed, cleaned and stowed.	✓	✓	✓	✓	✓	✓
SODASORB Dry	✓	✓	✓	✓	✓	✓
SODASORB Wet						
Comments: Minor corrosion spoting on units.						
11. Anodic protection device fitted. ok						
12. Test Day #6 (297 FSW) 26 Feb 81	✓	✓	✓	✓	✓	✓
Pre-dive tested for leaks.	ok	ok	ok	ok	ok	ok
Inspected-corrosion.	✓	✓	✓	✓	✓	✓
Inspected Impreglon peel.						
Rinsed, cleaned and stowed	✓	✓	✓	✓	✓	✓
SODASORB Dry	✓	✓	✓	✓	✓	✓
SODASORB Wet						
Comments:						
27 Feb 81						
13. Anodic protection device fitted. ok						

CHECK LIST
MK 12 SSDS-MANIFOLD TEST
FEBRUARY 1981

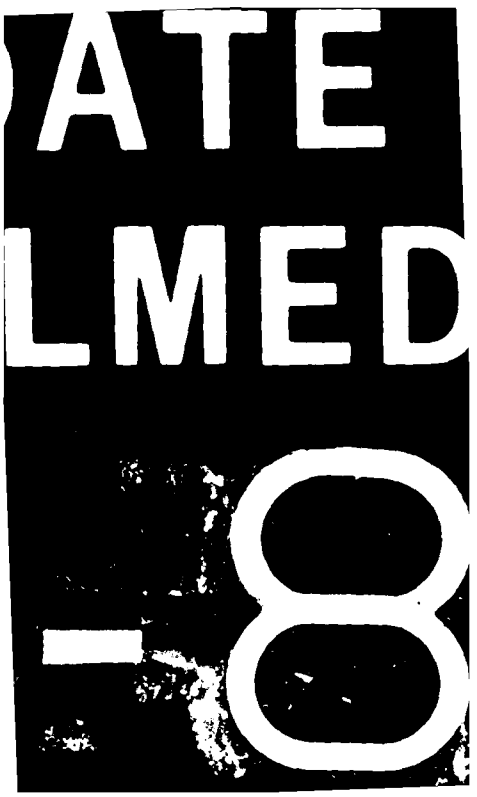
ROUTINE INSPECTIONS AND TESTS	MANIFOLDS					
	A	B	C	D	E	F
14. Test Day #7 (297 FSW)	✓	✓	✓	✓	✓	✓
Pre-dive tested for leaks.	✓	✓	✓	✓	✓	✓
Inspected-corrosion.	✓	✓	✓	✓	✓	✓
Inspected Impreglon peel.	✓	✓	✓	✓	✓	✓
Rinsed, cleaned and stowed.	✓	✓	✓	✓	✓	✓
SODASORB Dry	✓	✓	✓	✓	✓	✓
SODASORB Wet						
Comments:						
15. Anodic protection device fitted. 2 Mar 81 ok						
16. Test Day #8 (297 FSW)	✓	✓	✓	✓	✓	✓
Pre-dive tested for leaks.	✓	✓	✓	✓	✓	✓
Inspected-corrosion	ok	ok	ok	ok	ok	ok
Inspected Impreglon peel.	✓	✓	✓	✓	✓	✓
Rinsed, cleaned and stowed.	✓	✓	✓	✓	✓	✓
SODASORB Dry	✓	✓	✓	✓	✓	✓
SODASORB Wet						
Comments:						
17. Anodic protection device fitted. 3 Mar 81 ok						
18. Test Day #9 (297 FSW)	✓	✓	✓	✓	✓	✓
Pre-dive tested for leaks.	✓	✓	✓	✓	✓	✓
Inspected-corrosion.	✓	✓	✓	✓	✓	✓
Inspected Impreglon peel.	✓	✓	✓	✓	✓	✓
Rinsed, cleaned and stowed.	✓	✓	✓	✓	✓	✓
SODASORB Dry	✓	✓	✓	✓	✓	✓
SODASORB Wet						
Comments:						
19. Post dive tested for leaks on 4 Mar 81.	✓	✓	✓	✓	✓	✓
20. Placed in storage. 4 Mar 81	✓	✓	✓	✓	✓	✓

CHECK LIST
MK 12 SSDS-MANIFOLD TEST
FEBRUARY 1981

ROUTINE INSPECTIONS AND TESTS		MANIFOLDS					
		A	B	C	D	E	F
21. Storage Day 1 Inspected-corrosion. Inspected Impreglon peel.	4 Mar 81	ok	Small pin hole on	Small pin hole on	ok	ok	ok
22. Storage Day 2 Inspected-corrosion. Inspected Impreglon peel.	5 Mar 81	ok	sur-face "	sur-face "	ok	ok	ok
23. Storage Day 3 Inspected-corrosion. Inspected Impreglon peel.	6 Mar 81	ok	"	"	ok	ok	ok
24. Storage Day 4 Inspected-corrosion Inspected Impreglon peel.	7 Mar 81	ok	"	"	ok	ok	ok
25. Storage Day 5 Inspected-corrosion Inspected Impreglon peel.	8 Mar 81	ok	"	"	ok	ok	ok
26. Storage Day 6 Inspected-corrosion. Inspected Impreglon peel.	9 Mar 81	ok	"	"	ok	ok	ok
27. Storage Day 7 Inspected-corrosion. Inspected Impreglon Peel.	10 Mar 81	ok	"	"	ok	ok	ok
28. Storage Day 8 Inspected-corrosion. Inspected Impreglon peel.	11 Mar 81	ok	"	"	ok	ok	ok
29. Storage Day 9 Inspected-corrosion. Inspected Impreglon peel.	12 Mar 81	ok	"	"	ok	ok	ok
30. Storage Day 10 Inspected-corrosion. Inspected Impreglon peel	13 Mar 81	ok	"	"	ok	ok	ok
31. Storage Day 11 Inspected-corrosion. Inspected Impreglon peel.	14 Mar 81	ok	"	"	ok	ok	ok
32. Storage Day 12 Inspected-corrosion. Inspected Impreglon peel.	15 Mar 81	ok	"	"	ok	ok	ok

CHECK LIST
MK 12 SSDS-MANIFOLD TEST
FEBRUARY 1981

ROUTINE INSPECTIONS AND TESTS	MANIFOLDS					
	A	B	C	D	E	F
33. Storage Day 13 Inspected-corrosion. 16 Mar 81 Inspected Impreglon peel.	ok	Small pin hole on	Small pin hole on	ok	ok	ok
34. Storage Day 14 Inspected-corrosion. 17 Mar 81 Inspected Impreglon peel.	ok	sur-face "	sur-face "	ok	ok	ok
35. Post stowage tested for leaks on 21 Mar 81	NONE	----------	----------	----------	----------	----------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